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[Title of the Invention]
Dry Etching Apparatus And Plasma Chemical Vapor Deposition Apparatus

[CLAIMS]

1. A dry etching apparatus comprising a sealed chamber, which is evacuated using one or more vacuum evacuation pumps and which is provided with a port for introducing a reactive gas required for etching and a support gas and the like, wherein a part of the chamber is formed of a dielectric such as liquid crystal or the like, and wherein an etching substrate is etched by generating a plasma in a gas introduced into the chamber through the dielectric by means of an antenna provided on the atmosphere side and to which a high frequency is applied, and applying another high frequency to an electrode upon which the etching substrate is set within the chamber, the dry etching apparatus being characterized by the rotation of the antenna.

2. A plasma chemical vapor deposition apparatus comprising a sealed chamber, which is evacuated using one or more vacuum evacuation pumps and which is provided with a port for introducing a reactive gas required for etching and a support gas and the like, wherein a part of the chamber is

formed of a dielectric such as liquid crystal or the like, and wherein a thin layer is deposited on a substrate by generating a plasma in a gas introduced into the chamber through the dielectric by means of an antenna provided on the atmosphere side and to which a high frequency is applied, and applying another high frequency to an electrode upon which the substrate is set within the chamber, the plasma chemical vapor deposition apparatus being characterized by the rotation of the antenna.

[DETAILED DESCRIPTION OF THE INVENTION]

[TECHNICAL FIELD OF THE INVENTION]

The present invention relates to a dry etching apparatus and a chemical vapor deposition (hereinafter abbreviated as "CVD") apparatus for use in the processes of manufacturing semiconductor integrated circuits (hereinafter abbreviated as "IC"), liquid crystal display devices (hereinafter abbreviated as "LCD"), thin film magnetic heads (hereinafter abbreviated as "TFH") and the like.

[BACKGROUND ART]

The IC, LCD, TFH and the like are manufactured by depositing and patterning in a required configuration a thin film provided with various types of functionalities on a suitable substrate. A so-called dry etching apparatus is used to remove the unnecessary areas; plasma is generated in a dilute gas and electrically accelerated to physically remove the etching substance, and the plasma and etched substance chemically react such that the etching substance is removed as a volatile compound. Although CVD and physical vapor deposition (hereinafter abbreviated to "PVD"), which includes spattering and vacuum evaporation deposition, may

be used to deposit a thin film, the CVD method is mainly used in the present invention. The CVD method has been a particular focus in recent years as a method capable of forming thin layer compounds, which decompose in the PVD, forming delicate thin films possessing a three-dimensional network.

A plasma generating mechanism is provided as one device controlling the performance of these apparatuses, and in recent years attention has been focused on the simply constructed inductively coupled-type plasma (hereinafter abbreviated as "ICP") device which is capable generating high density plasma. This device excites a gas introduced into a vacuum device to generate plasma by applying high frequencies to an external antenna and coil, so as to inductively couple the antenna and gas through a dielectric. Since the ICP device provides as much as two orders higher plasma density compared to the typical parallel plate electrode-type plasma generator, etching speed and thin film deposition speed are remarkably improved. Among these, antennae used for the high frequency application which having a minimum of one turn also have minimal power loss due to the small inductance, and are therefore more efficient.

The one-turn type ICP apparatus is described using Figs. 3 and 4. Figs. 3 and 4 differ only in the bell-shaped and plate-shaped configurations of the dielectric part, and the basic principle is identical. Both the etching apparatus and the CVD apparatus use reactive and inactive gases as the gases introduced for etching except that silane and methane are used as material gases in CVD. The basic construction of the apparatus includes a chamber 4 provided with a quartz

bell jar 2 (Fig. 3) or quartz plate 3 (Fig. 4), an electrode 12 for applying a bias and holding a slider substrate 1, exhaust port 6 connected to a vacuum pump, a gas introducing port for supplying an etching gas and material gas, and a one-turn (or one-winding) antenna 5 for plasma excitation and the like. The antenna 5 is connected to a 13.56 MHz high frequency power source 11 through an impedance matching box (not shown), and the electrode 12 is connected to a 400 kHz bias power source 14 through a blocking capacitor.

The functionality of the apparatus is described by way of an example of etching. First, the substrate 1 to be etched is placed on the electrode 12, and the interior of the chamber 4 is evacuated by a vacuum pump. Thereafter, an etching gas is introduced through the gas introduction port 7, and high-frequency power is applied by the high-frequency power source 11 to the antenna 5, so as to excite the introduced gas and generate plasma. Subsequently, when separate high-frequency power is applied to the electrode 12 by the bias power source 14, the electrode is automatically induced to have a negative charge by means of the action of the blocking capacitor 13 and the surface ratio of the electrode and the grounded chamber. This is called a self-bias effect. Since ions in the plasma mainly have a positive charge, the ions flow toward the substrate 1 and the electrode 12. The substrate is etched by these ions. In the CVD apparatus, if a material gas rather than an etching gas is introduced through the gas introduction port 7, a thin film of the introduced material gas is deposited on the substrate 1.

The one-turn type ICP apparatus described above has a relatively simple structure, and the uniformity of the

plasma is a problem because the antenna 5 has one turn. That is, the coil-like circular antenna naturally produces a gap at one location. Since this gap is unavoidable because the coil-like antenna is circularly formed, the irregularity of the plasma produced by the gap area is linked to fluctuation in etching speed and deposition speed. Since many etching processes used for ICs and the like often provide a so-called etching stop layer of material which is etch-resistant beneath the etching layer, the problem of fluctuation in etching speed does not arise, although element miniaturization and the possibility of causing insulation destruction due to the difference in electric potential through the non-uniform plasma are indicated. Furthermore, since there is no etching stop layer when, for example, etching a slider member used in a hard disk drive, a problem arises inasmuch as variation of the etching depth is directly linked to variation in the floating height of the head. In CVD, however, the film deposition thickness will differ due to the non-uniform plasma, and is linked to variable product quality.

Although the number of turns of the antenna can be increased to ensure plasma uniformity, efficiency will be reduced due to an increase in inductance, indicating that the overall etching speed and deposition speed will be reduced.

[PROBLEMS THE INVENTION IS TO SOLVE]

As described above, CVD apparatuses and dry etching apparatuses for ICP using a one-turn antenna for efficiency have a uniformity problem, and it is desirable to have a CVD apparatus and dry etching apparatus which provided with both efficiency and uniformity.

In view of these problems, the present invention provides a CVD apparatus and dry etching apparatus providing both efficiency and uniformity.

[MEANS FOR SOLVING THE PROBLEMS]

The antenna gap moves over time due to the rotation of the one-turn antenna, such that the region of weak plasma is not stationary at one location. The structures of the apparatuses are shown in Fig. 3 and Fig. 4, and include a motor for rotating the antenna and an electrical connection mechanism for supplying electrical power to the antenna. In this way the reduction in efficiency can be minimized, and a uniform etching speed and deposition speed can be obtained over a wide region within the chamber.

The effect of the present invention is described using Fig. 1 and Fig. 2. Fig. 1 and Fig. 2 show an etching apparatus and CVD apparatus of the present invention, which add an antenna rotation mechanism to the types of conventional apparatuses shown in Fig. 3 and Fig. 4. During etching and CVD, first, the substrate 1 is placed on the electrode 12, and the interior of the chamber 4 is evacuated by the vacuum pump. Thereafter, an etching gas or CVD material gas is introduced through the gas introduction port 7, a high-frequency power is supplied from the high-frequency power source 11 to the antenna 5, and the introduced gas is excited to generate a plasma. At this time, the motor 10 is rotated. The rotation of the motor 10 is slowed by phase control and gears, and transmitted to the antenna through a conductive disk. The high-frequency power used for plasma excitation from the high-frequency power source 11 is transmitted by a brush 9 to a ring formed on

the conductive disk and connected to the antenna. Subsequently, another high-frequency power is supplied from the bias power source 14 to the electrode 12, and etching or CVD begins when the self-bias effect induces ions in the plasma to bombard the substrate 1. Whether etching or CVD is performed is determined by the type of gas introduced through the gas introduction port 7. Since the antenna 5 normally rotates, the non-uniformity of the antenna shape is not spatially fixed, such that the plasma formed within the chamber 4 is ensured of having a uniformity among the ions reaching the substrate 1, so as to improve the surface distribution of the etching speed and CVD deposition speed.

The present invention described above is capable of improving etching and CVD deposition uniformity without reducing efficiency of the ICP apparatus provided with a one-turn antenna. Embodiments are described below.

[EMBODIMENTS]

A dry etching including a sealed chamber, which is evacuated using one or more vacuum evacuation pumps and which is provided with a port for introducing a reactive gas required for etching and a support gas and the like, wherein a part of the chamber is formed of a dielectric such as liquid crystal or the like, and wherein an etching substrate is etched by generating a plasma in a gas introduced into the chamber through the dielectric by means of an antenna provided on the atmosphere side and to which a high frequency is applied, and applying another high frequency to an electrode upon which the etching substrate is set within the chamber, and wherein the antenna rotates.

[EXAMPLES]

(First Example)

The example described below pertains to the etching of an aluminum-titanium carbide composite ceramic substrate using the ICP apparatus of the present invention. The ICP apparatus shown in Fig. 1 was used. The diameter of the quartz bell jar 2 is 20 cm. First, the aluminum-titanium carbide substrate 1 to be etched was placed on the electrode 12, and the interior of the chamber 4 was evacuated by the vacuum pump. A resist mask (not shown in the drawing) was formed beforehand on the substrate 1 so as to obtain a desired shape. Thereafter, a gas mixture of boron trichloride and argon in a 4:6 ratio was introduced through the gas introduction port 7 as an etching gas, and the pressure was maintained at 10 mtorr. High-frequency power of 13.56 MHz and 500 W was supplied from the high-frequency power source 11 to the antenna 5 to excite the introduced gas to generate plasma. At this time the motor 10 was rotated at 10 rpm so as to rotate the antenna 5, and the high-frequency power was transmitted to the antenna through the brush 9 and the conductive disk 8. Thereafter, a high-frequency power of 400 kHz and 100 W was supplied from the bias power source 14 to the electrode 12, and ions within the plasma bombarded the substrate by the self-bias effect, and etching began. After etching ended and the resist was peeled away and substrate washed, the amount of etching was measured and it was found that a highly uniform layer having only a ±3% variation from the average etching speed of 300 nm/min was obtained in a square region 100 mm on a side.

(Example 2)

Another example described below pertains to the etching of an aluminum-titanium carbide composite ceramic substrate

using the ICP apparatus of the present invention. The ICP apparatus shown in Fig. 2 was used. The diameter of the quartz plate 3 is 22 cm. First, the aluminum-titanium carbide substrate 1 to be etched was placed on the electrode 12, and the interior of the chamber 4 was evacuated by the vacuum pump. A resist mask (not shown in the drawing) was formed beforehand on the substrate 1 so as to obtain a desired shape. Thereafter, a gas mixture of boron trichloride and argon in a 4:6 ratio was introduced through the gas introduction port 7 as an etching gas, and the pressure was maintained at 10 mtorr. High-frequency power of 13.56 MHz and 500 W was supplied from the high-frequency power source 11 to the antenna 5 to excite the introduced gas to generate plasma. At this time the motor 10 was rotated at 10 rpm so as to rotate the antenna 5, and the high-frequency power was transmitted to the antenna through the brush 9 and the conductive disk 8. Thereafter, a high-frequency power of 400 kHz and 100 W was supplied from the bias power source 14 to the electrode 12, and ions within the plasma bombarded the substrate by the self-bias effect, and etching began.

After etching ended and the resist was peeled away and the substrate washed, the amount of etching was measured and it was found that a highly uniform layer having only a ±3% variation from the average etching speed of 340 nm/min was obtained in a square region 100 mm on a side.

(Example 3)

The example described below pertains to the deposition of a diamond carbide (hereinafter abbreviated as "DLC") layer on a silicone substrate using the ICP apparatus of the present invention. The ICP apparatus shown in Fig. 1 was

used as the CVD apparatus. The diameter of the quartz bell jar 2 is 20 cm. First, a 4-inch round substrate 1 was placed on the electrode 12, and the interior of the chamber 4 was evacuated by the vacuum pump. Thereafter, methane was introduced through the gas introduction port 7 as a material gas, and the pressure was maintained at 1 torr. High-frequency power of 13.56 MHz and 500 W was supplied from the high-frequency power source 11 to the antenna 5 to excite the introduced gas to generate plasma. At this time the motor 10 was rotated at 10 rpm so as to rotate the antenna 5, and the high-frequency power was transmitted to the antenna through the brush 9 and the conductive disk 8. Thereafter, a high-frequency power of 400 kHz and 70 W was supplied from the bias power source 14 to the electrode 12, and ions within the plasma bombarded the substrate by the self-bias effect, and deposition began.

After deposition ended, the thickness of the layer was measured using a spectral ellipsometer and it was found that a highly uniform DLC layer having only a ±3% variation across the entire 4-inch round surface was formed.

(Example 4)

The example described below pertains to the deposition of a DLC layer on a silicone substrate using the ICP apparatus of the present invention. The ICP apparatus shown in Fig. 2 was used as the CVD apparatus. The diameter of the quartz plate 3 is 22 cm. First, a 4-inch round substrate 1 was placed on the electrode 12, and the interior of the chamber 4 was evacuated by the vacuum pump. Thereafter, methane was introduced through the gas introduction port 7 as a material gas, and the pressure was maintained at 1 torr. High-frequency power of 13.56 MHz and 500 W was

supplied from the high-frequency power source 11 to the antenna 5 to excite the introduced gas to generate plasma. At this time the motor 10 was rotated at 10 rpm so as to rotate the antenna 5, and the high-frequency power was transmitted to the antenna through the brush 9 and the conductive disk 8. Thereafter, a high-frequency power of 400 kHz and 70 W was supplied from the bias power source 14 to the electrode 12, and ions within the plasma bombarded the substrate by the self-bias effect, and deposition began.

After deposition ended, the thickness of the layer was measured using a spectral ellipsometer and it was found that a highly uniform DLC layer having only a ±3% variation across the entire 4-inch round surface was formed.

(Example 5)

The example described below pertains to the etching of an aluminum-titanium carbide ceramic substrate using the ICP apparatus shown in Fig. 3. This ICP apparatus is identical in structure, size and the like to the apparatus used in Example 1 with the exception that the antenna 5 did not rotate. When the aluminum-titanium carbide substrate 1 was etched using the same process as described in Example 1 and using the ICP apparatus shown in Fig. 3, there was ±10% variation in the amount of etching in a square region 100 mm on a side, and the obtained result clearly had poorer uniformity compared to Example 1. Etching speed was particularly reduced in the region near the break in the circular arc of the antenna 5.

(Example 6)

The example described below pertains to the etching of an aluminum-titanium carbide ceramic substrate using the ICP

apparatus shown in Fig. 4. This ICP apparatus is identical in structure, size and the like to the apparatus used in Example 2 with the exception that the antenna 5 did not rotate. When the aluminum-titanium carbide substrate 1 was etched using the same process as described in Example 2 and using the ICP apparatus shown in Fig. 4, there was ±10% variation in the amount of etching in a square region 100 mm on a side, and the obtained result clearly had poorer uniformity compared to Example 2. Etching speed was particularly reduced in the region near the break in the circular arc of the antenna 5.

(Example 7)

The example described below pertains to the deposition of a DLC layer using the ICP apparatus shown in Fig. 3. This ICP apparatus is identical in structure, size and the like to the apparatus used in Example 3 with the exception that the antenna 5 did not rotate. When the DLC layer was deposited on the silicone substrate using the same process as in Example 3 and using the ICP apparatus shown in Fig. 3, there was ±10% variation in the layer across the entirety of the 4-inch round surface, and the obtained result clearly had poorer uniformity compared to Example 3. The layer thickness was particularly reduced in the region near the break in the circular arc of the antenna 5.

(Example 8)

The example described below pertains to the deposition of a DLC layer using the ICP apparatus shown in Fig. 4. This ICP apparatus is identical in structure, size and the like to the apparatus used in Example 4 with the exception that the antenna 5 did not rotate. When the DLC layer was deposited on the silicone substrate using the same process

as in Example 4 and using the ICP apparatus shown in Fig. 4, there was ±10% variation in the layer across the entirety of the 4-inch round surface, and the obtained result clearly had poorer uniformity compared to Example 4. The layer thickness was particularly reduced in the region near the break in the circular arc of the antenna 5.

It is to be clearly understood that the ICP apparatus of the present invention is not limited to the processes and conditions described in the examples, and may be applicable insofar as the process uses an ICP apparatus.

[EFFECT OF THE INVENTION]

The present invention as described above improves the uniformity without reducing the efficiency of a high-performance ICP apparatus provided with a one-turn antenna. Moreover, the present invention broadly provides high accuracy in manufacturing processes, which require so-called dry processing, such as IC, LCD, TFH and the like.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Fig. 1 is a conceptual drawing showing an example of the ICP apparatus of the present invention;

Fig. 2 is a conceptual drawing showing another example of the ICP apparatus of the present invention;

Fig. 3 is a conceptual drawing showing an example of a conventional ICP apparatus; and

Fig. 4 is a conceptual drawing showing another example of a conventional ICP apparatus.

[DESCRIPTION OF THE REFERENCE NUMBERS]

1) Substrate

2) Quartz bell jar

3) Quartz plate

4) Chamber

5) Antenna

6) Exhaust port

7) Gas introduction port

8) Conductive disk

9) Brush

10) Motor

11) High-frequency power source

12) Electrode

13) Blocking capacitor

14) Bias power source

造、大きさ等、実施例4で用いた装置と同一である。図4に示したＩＣＰ装置を用いて実施例4と同一の工程によりＤＬＣ膜をシリコンの基板1上に堆積させたところ、4インチ丸の全面にわたりバラツキ±１０％の膜が得られ、実施例4と比較して明らかに均一性の劣る結果が得られた。特に、アンテナ5の円弧が切れた部分に近い領域の膜厚が小さかった。

【００２５】以上の実施例で用いた工程、条件は記載したものに限るものでなく、ＩＣＰ装置を用いて行われていた工程であれば、本発明によるＩＣＰ装置が適用できることは言うまでもない。

【００２６】

【発明の効果】以上述べたように本発明によれば、高効率の１ターンアンテナを備えるＩＣＰ装置の効率を低下させることなしに均一性を向上させることができる。それゆえＩＣやＬＣＤ、ＴＦＨなど、いわゆるドライプロセスを必要とする製造工程の高精度化に広く貢献するものである。

【図面の簡単な説明】

【図１】本発明によるＩＣＰ装置の一例を示す概念図である。

【図２】本発明によるＩＣＰ装置の別の例を示す概念図である。

【図３】従来のＩＣＰ装置の一例を示す概念図である。

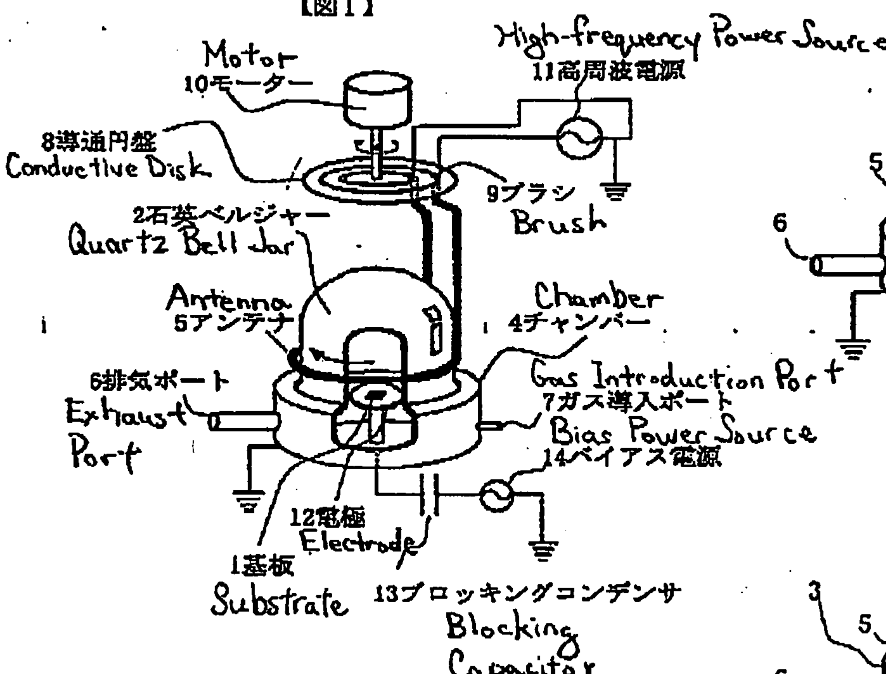
【図４】従来のＩＣＰ装置の別の例を示す概念図である。

【符号の説明】

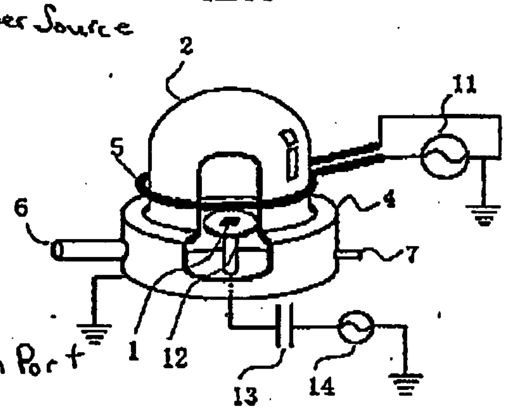
1　基板
2　石英ベルジャー
3　石英板
4　チャンバー
5　アンテナ
6　排気ポート
7　ガス導入ポート
8　導通円盤
9　ブラシ
１０　モーター
１１　高周波電源
１２　電極
１３　ブロッキングコンデンサ
１４　バイアス電源

Drawings

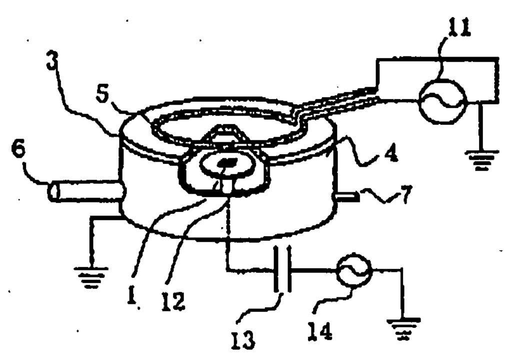
[Fig.1]
【図１】



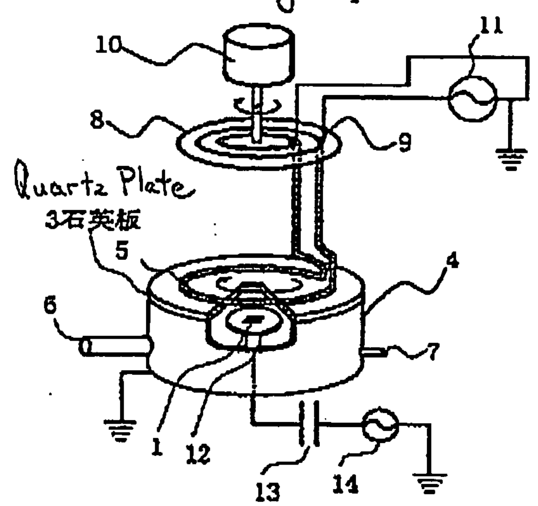
[Fig.3]
【図３】



[Fig.4]
【図４】



【図2】 [Fig. 2]



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